SI

Synergetic Industries

Agriculture, Water and Energy

Desalination Workshop

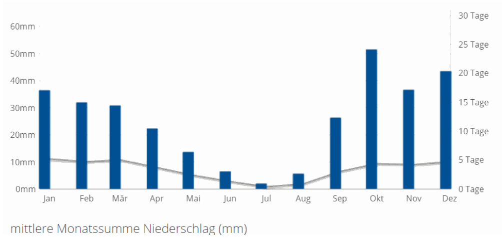
Desalination as a core element for Investment in arid regions and sustainable development in Tunisia's South

Overview

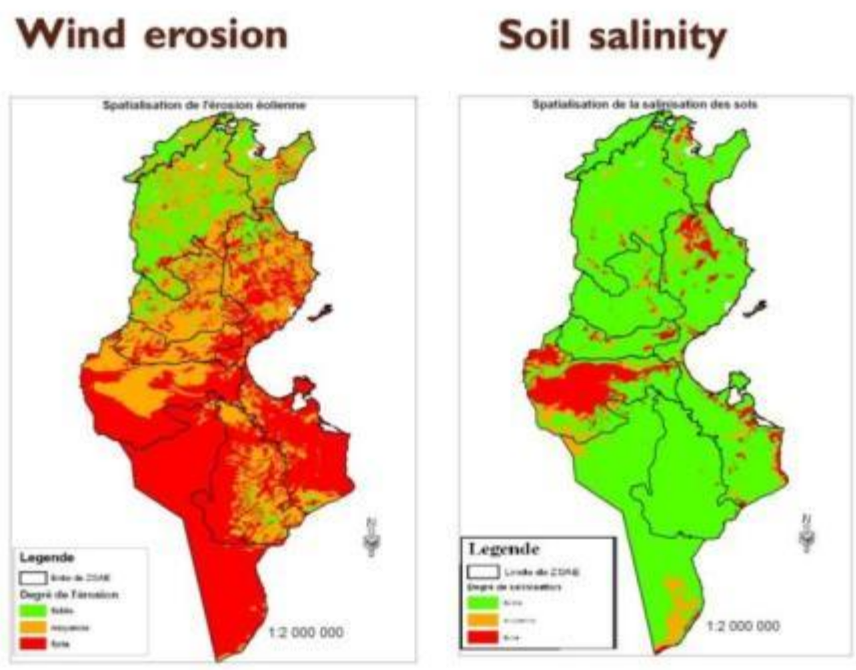
- Situation and demand for desalination
- Methodology
- Thermodynamics
- Calculations and present work
- Regional Development and objectives

The agricultural conditions

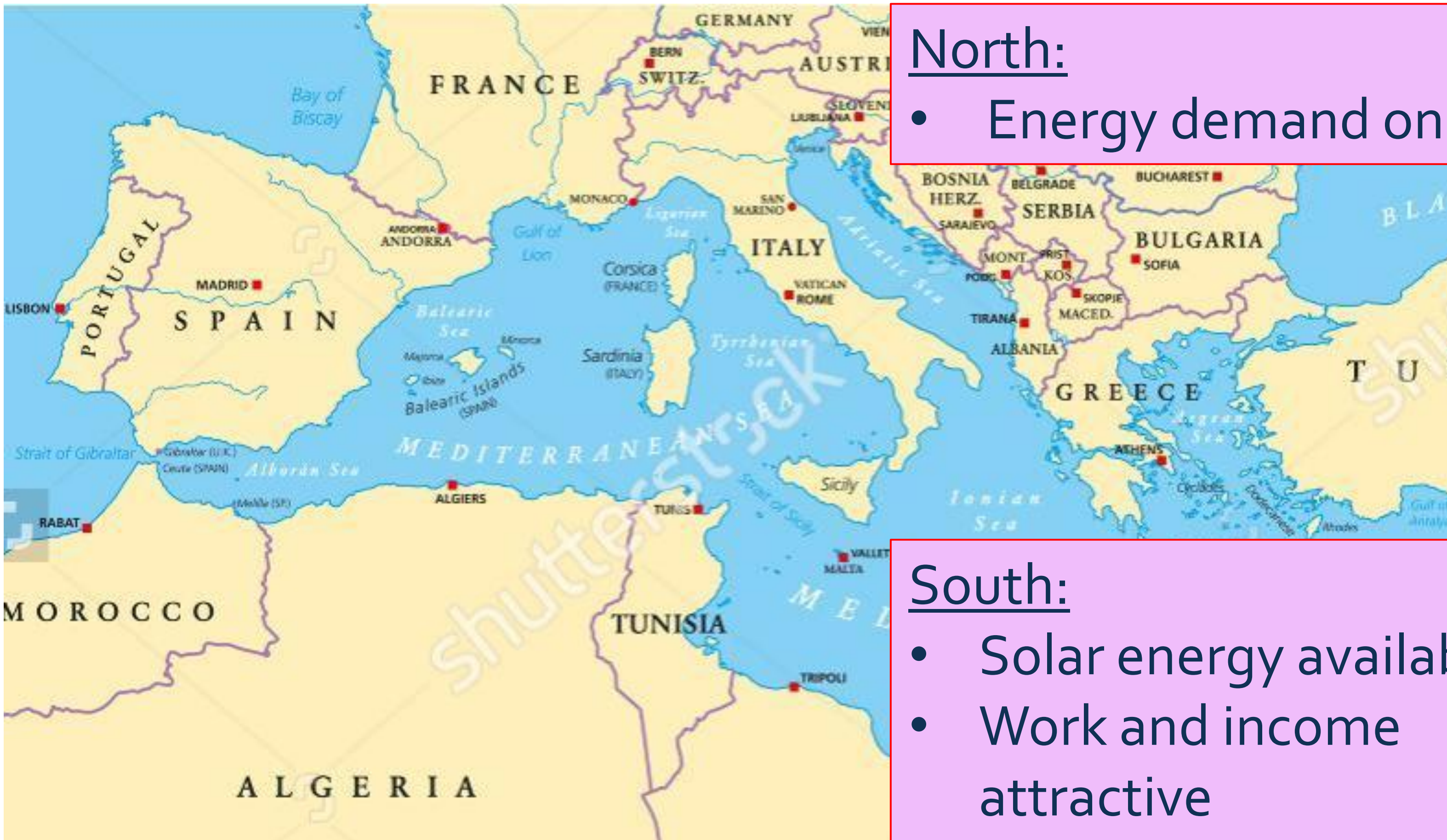
Precipitation



Soil preservation; Wind and Salinity



The Strategic situation



North:
- Energy demand on call

South:
- Solar energy available
- Work and income attractive

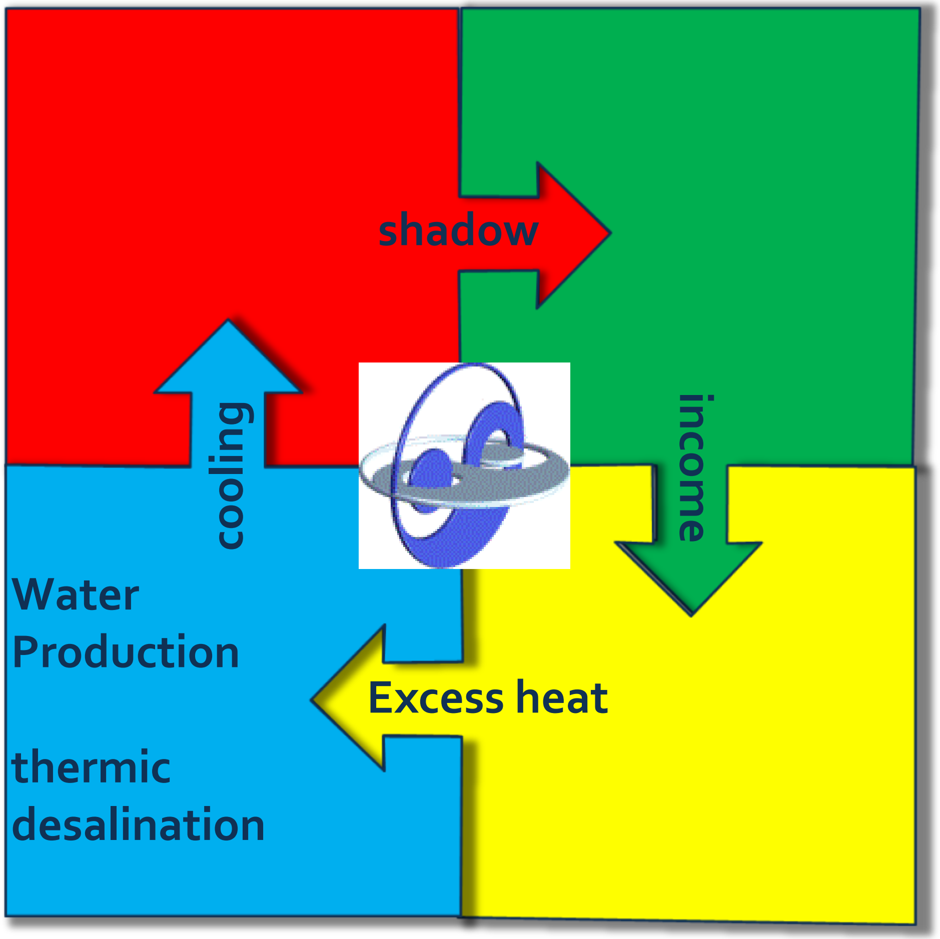
Answer to Water scarcity

Water Conservation

Water Production

Synergy and Recuperation

PV
Electric energy



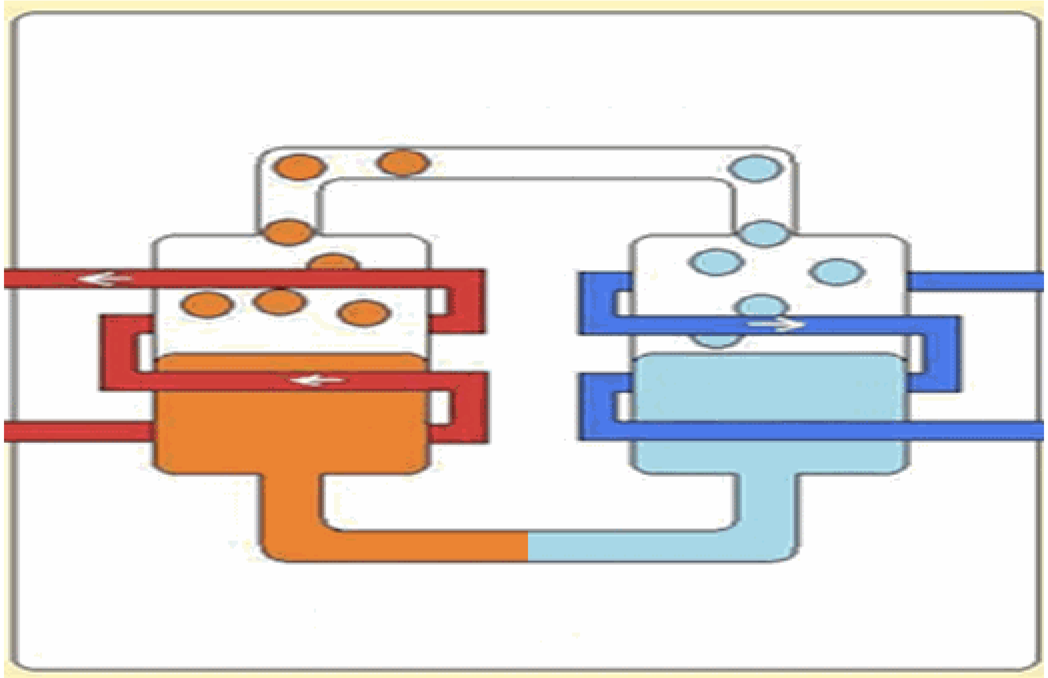
Agriculture
pomiculture
horticulture

Desalination

Collectors

H2 production
on long run

Basic Thermodynamics of solar thermic desalination

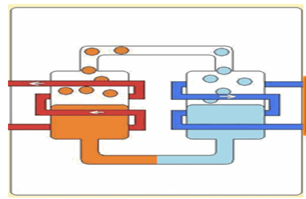


1) Heating and Evaporation of Seawater

2) Cooling and Condensation of distillat

Basic Thermodynamics of solar thermic desalination

$\dot{m}_L h_2 T_2$



$\dot{m}_L \quad T_3 \quad x_{sat}$

x_2

1) Heating and Evaporation of Seawater

$$E = E_m \cdot A$$

2) Cooling and Condensation of distillat

$\dot{m}_L \; T_1 \, h_1$

$\dot{m}_{w2,out}$

$\dot{m}_{w1,in} \; h_w \; T_w$

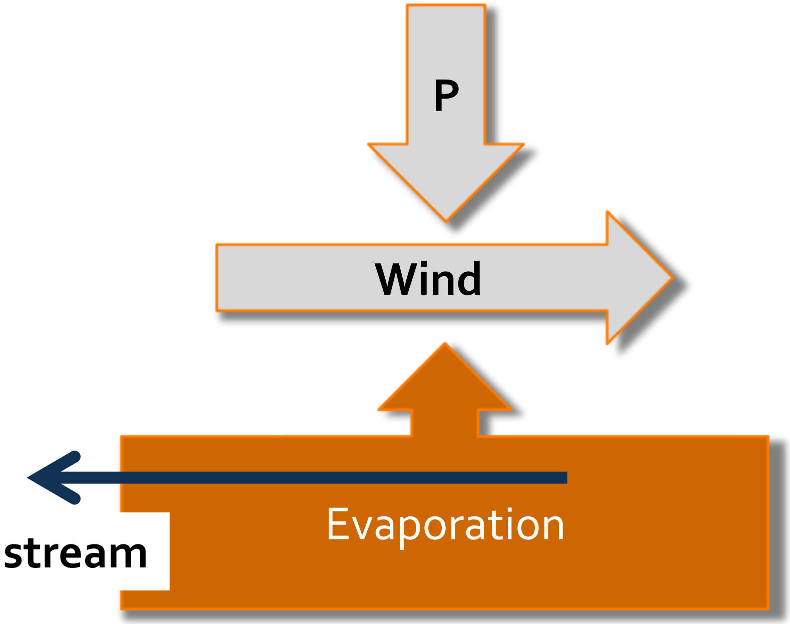
Energy $\quad \dot{m}_L h_1 + \dot{m}_{w1,in} h_w = \dot{m}_L T_w \quad \dot{m}_L h_2 - \dot{m}_{w2,out} h_w = \dot{m}_L h_{sat}(T_3)$

Mass $\quad \dot{m}_L x_1 + \dot{m}_{w1,in} = \dot{m}_L x_2 \quad \dot{m}_L x_2 - \dot{m}_{w2,out} = \dot{m}_L x_{sat}(T_3)$

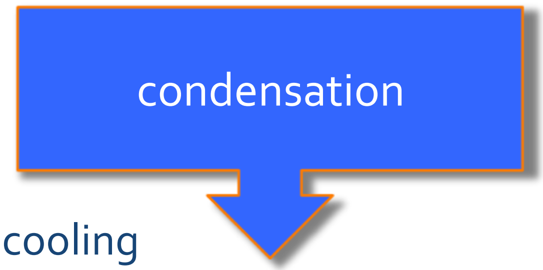
Methodology: Influences

1) Heating and Evaporation of Seawater

- Next slide



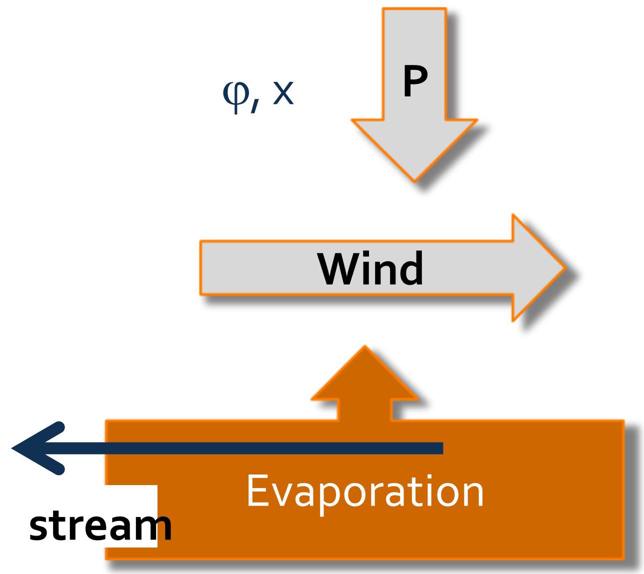
2) Cooling and Condensation of distillat



- cooling
- pressure
- freezing

Methodology: Influence on evaporation in detail

- **Temperature** of **Sea** water ϑ_W
- **Flow** or stream of sea water (negl.)
- **Chemistry** of sea water (negl.)
- **Temperature** of **Gas** at surface ϑ_L
- Air **pressure** above sea water P
- **Wind** or Flow of air above sea water v
- **Moisture** of air φ, x



$$E_m = \left[\frac{kg}{m^2, day}\right]$$

Methodology: evaporation;
Semi Empiric mathematical model

- Description through Equation

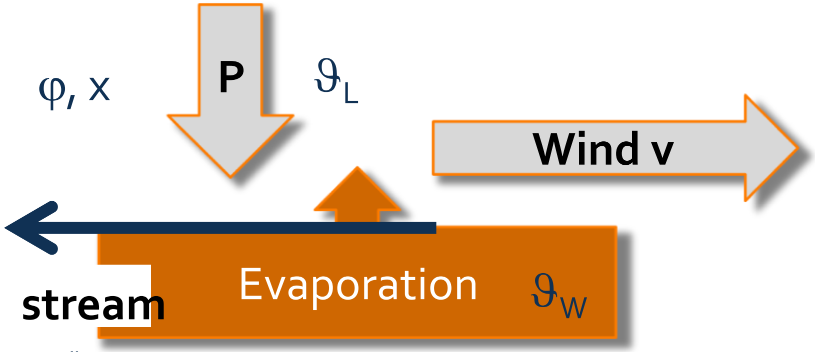
$$E_m = p_0 \left[e^{\left(\frac{c_1 \vartheta_W}{c_2 + \vartheta_W}\right)} - \varphi \cdot e^{\left(\frac{c_1 \vartheta_L}{c_2 + \vartheta_L}\right)} \right] \cdot \frac{k_1 + k_2 v^{\alpha}}{k_1 + k_2 \vartheta_w} k_e$$

$p_0 = p_{evap,T=0°C}$

ϑ_w

v

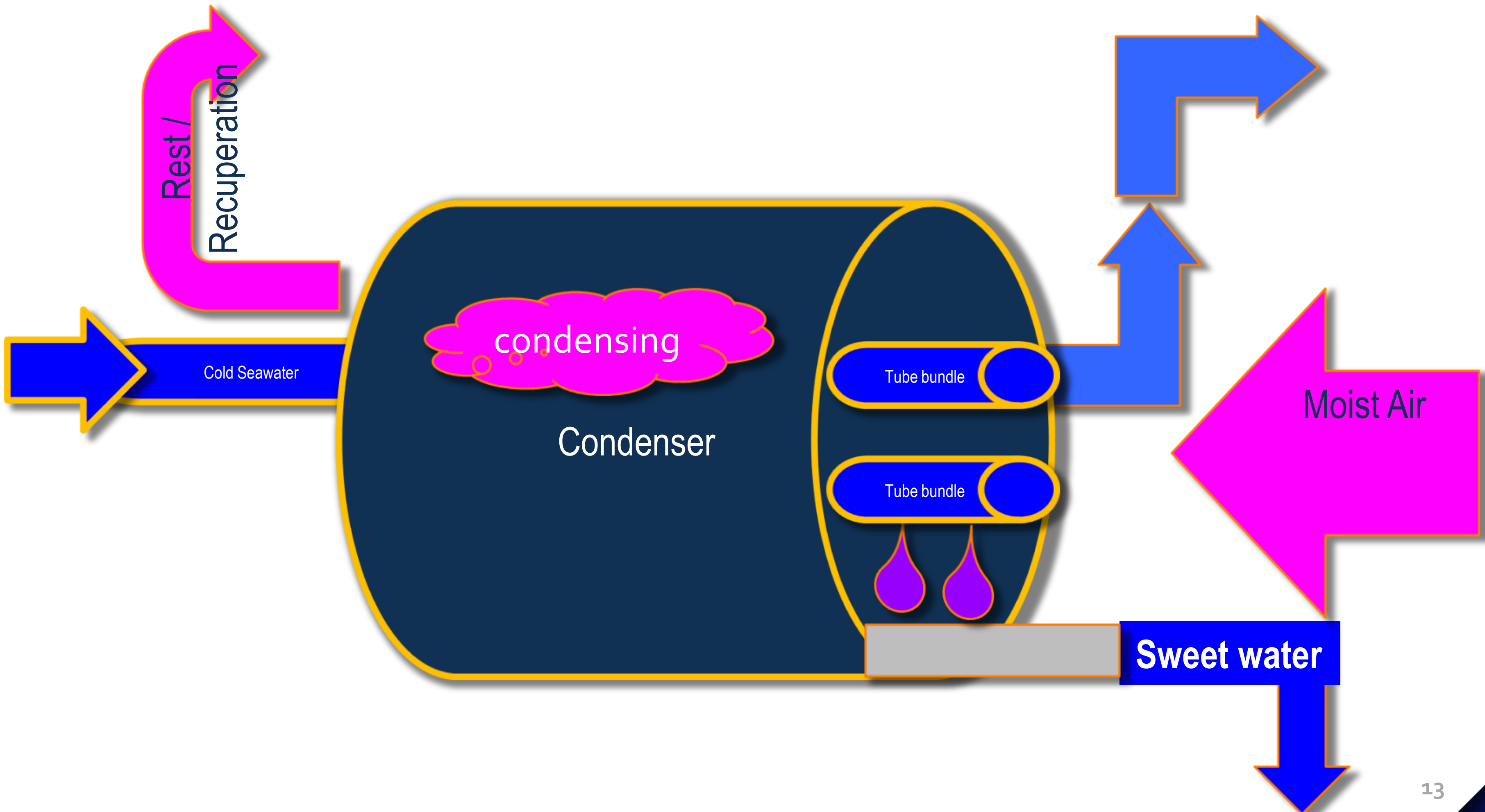
$k_e = a_1 + a_2 \cdot \varrho \sim 1{,}14$



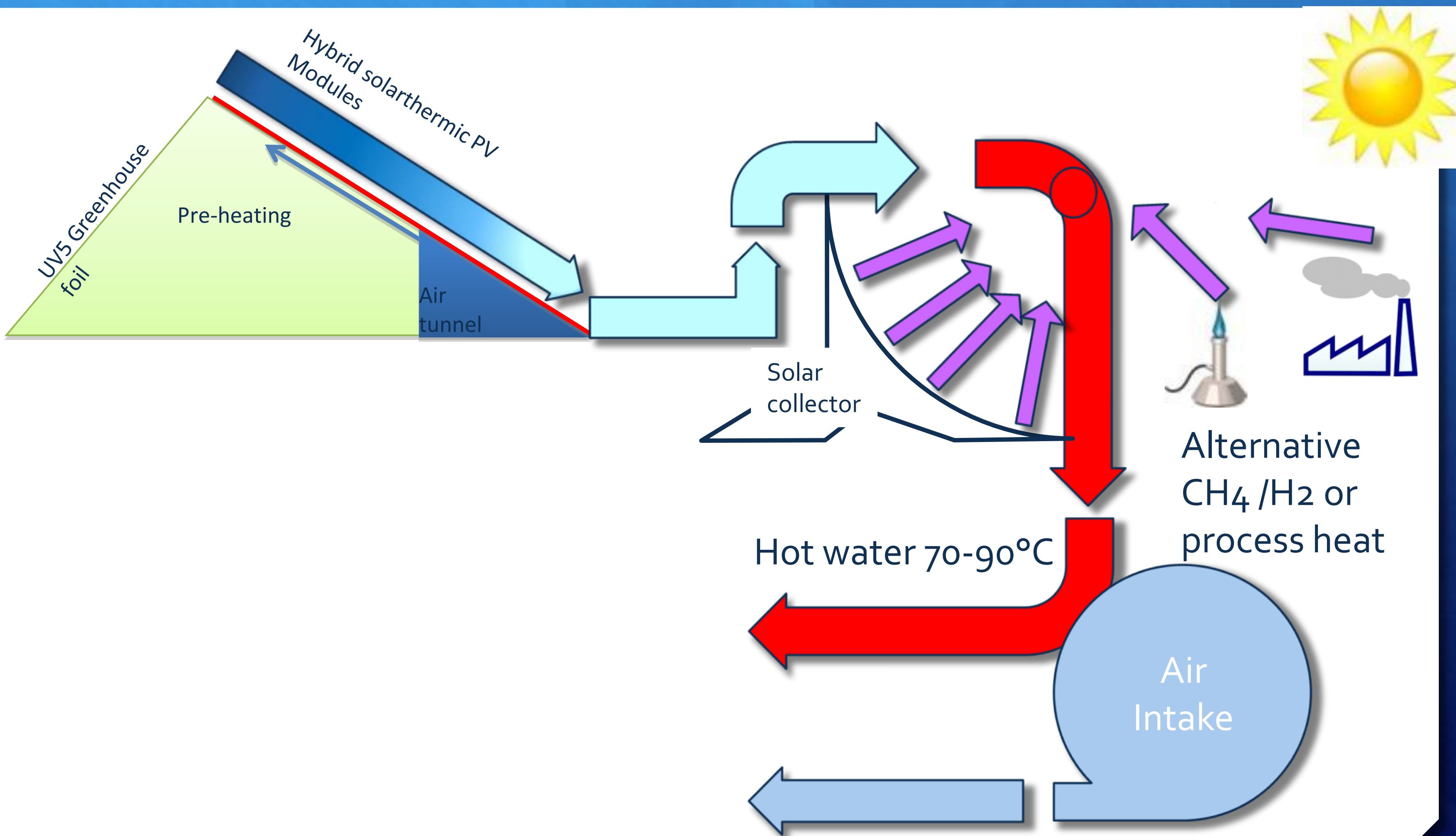
Simulation Optimum

2009: Giebler; Knechtel; TU Dresden: ABHÄNGIGKEIT DER VERDUNSTUNG AUS GALVANOTECHNISCHEN PROZESS- / SPÜLLÖSUNGEN

Desalinating Saltwater cooled PV-Greenhouses through heat recuperation

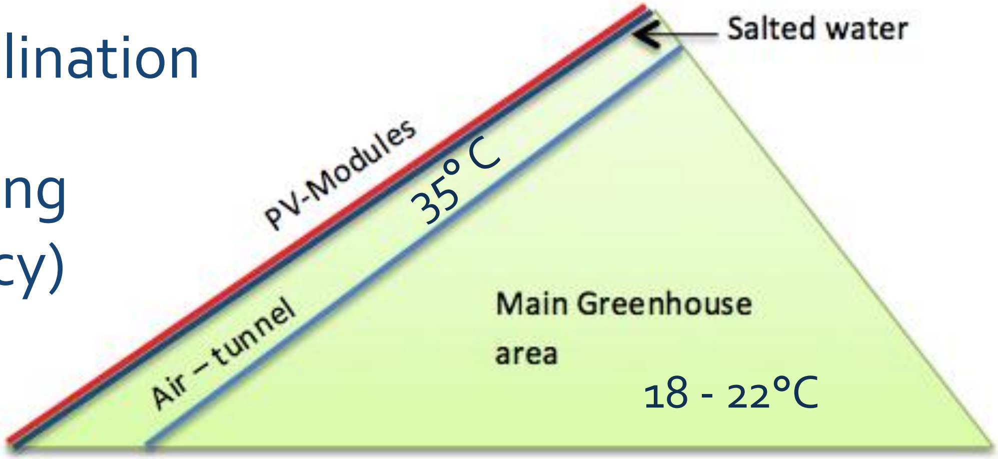


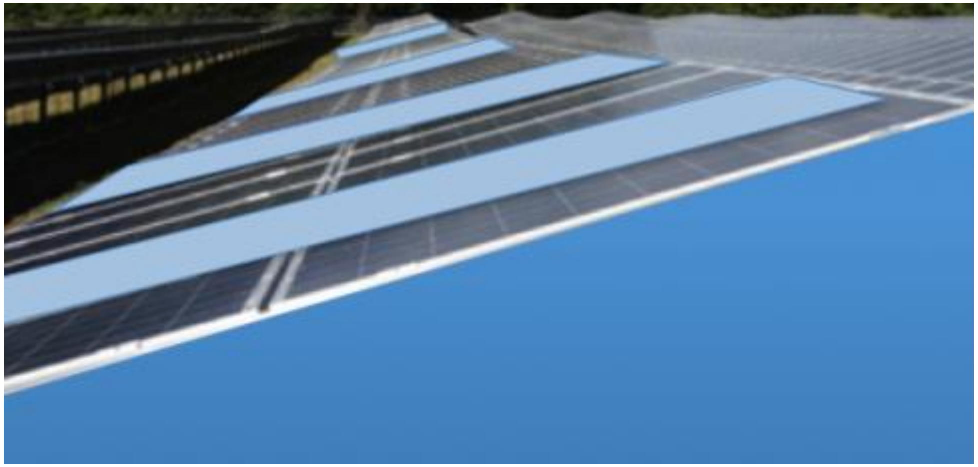
Desalinating Saltwater cooled PV-Greenhouses through heat recuperation



PV-Greenhouses

- Additional thermic desalination
- Backside seawater cooling (with higher PV efficiency)
- Seperation Saltwater
- Cooled main area
- ONLY partially shaded suitable for plants





Hybrid PV Panels

<u>Collecting :</u>

1) solar-electric power (cooled and fortified)

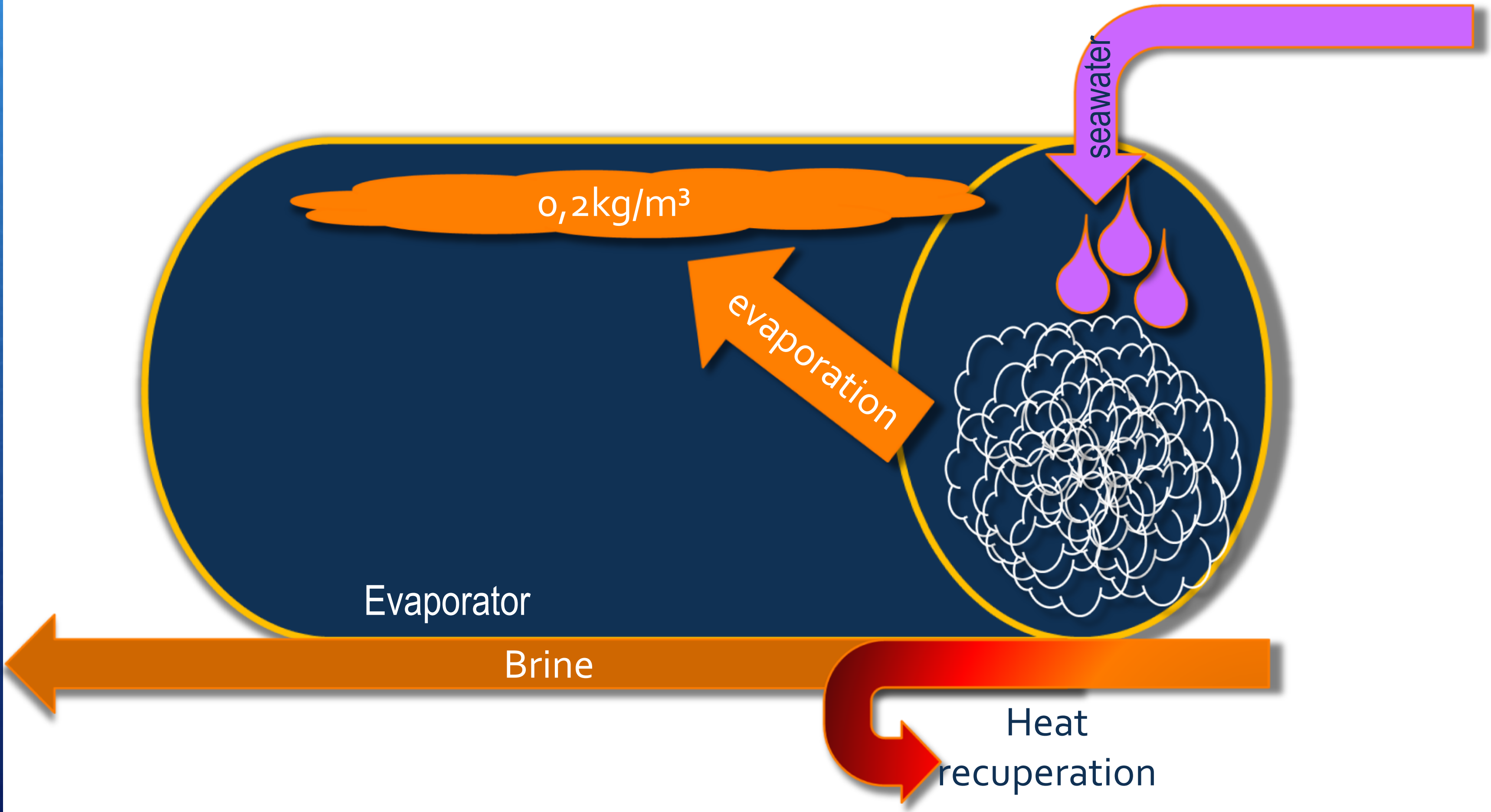
and

2) heat

Process heat recuperated for desalination

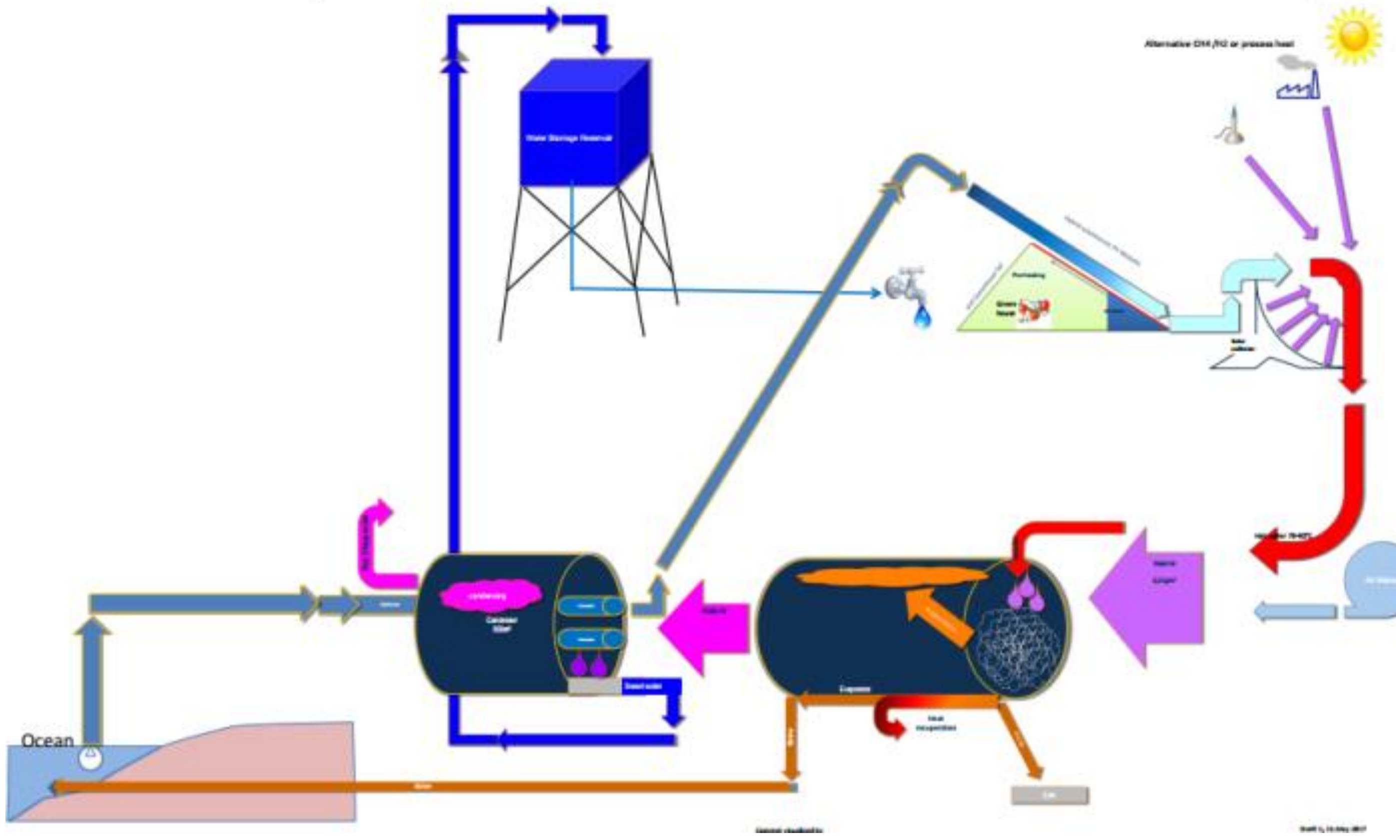
- Excess heat from Drying of agricultural products for evaporation
  - E.g. : Apricots
  - E.g. : medical herbs
- Electrolysis producing H_2 / O_2 and their compression
- Cooling in condensation
  - Expansion

Desalinating Saltwater cooled PV-Greenhouses through heat recuperation



Complete system overview

Recuperative Desalination Concept



Calculations and projections

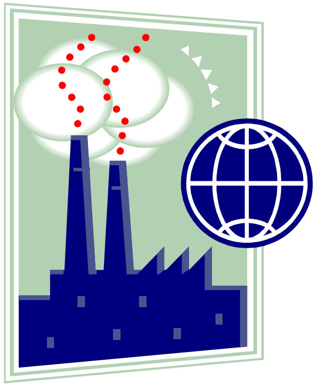
- Input:
  - Water flow: 17 Kg/sec , Air flow: 15 Kg/sec
- Intermediary:
  - Heat exchange: 3,9MW
  - Temperature sea water: 80°C
  - Temperature air: 70°C
- Output:
  - 50m³ destilled water / day on average
    sufficient for 1-2ha with efficient water management
  - Brine utilized for salt production
  - 2000m² greenhouse
  - PV Output: 160 kW through 680 hybrid panels each 0,8kw heat
- Operation
  - Sustainable operation with technology from within Tunisia
  - Operating costs amount to 1/10th of Reverse Osmosis!

Desalination and a way forward

Conventional methods low investment, but high operating costs (**import Membrane not necessary**)

Affordable solar-thermic Desalination through
1. waiving of membrane
2. Recuperation
3. Operation at p=1bar
4. Longterm Production in Tunisia

Practical Evaluation



Utilization of already existing technology, adaptation and enhancement and adaptation to Tunisian condition

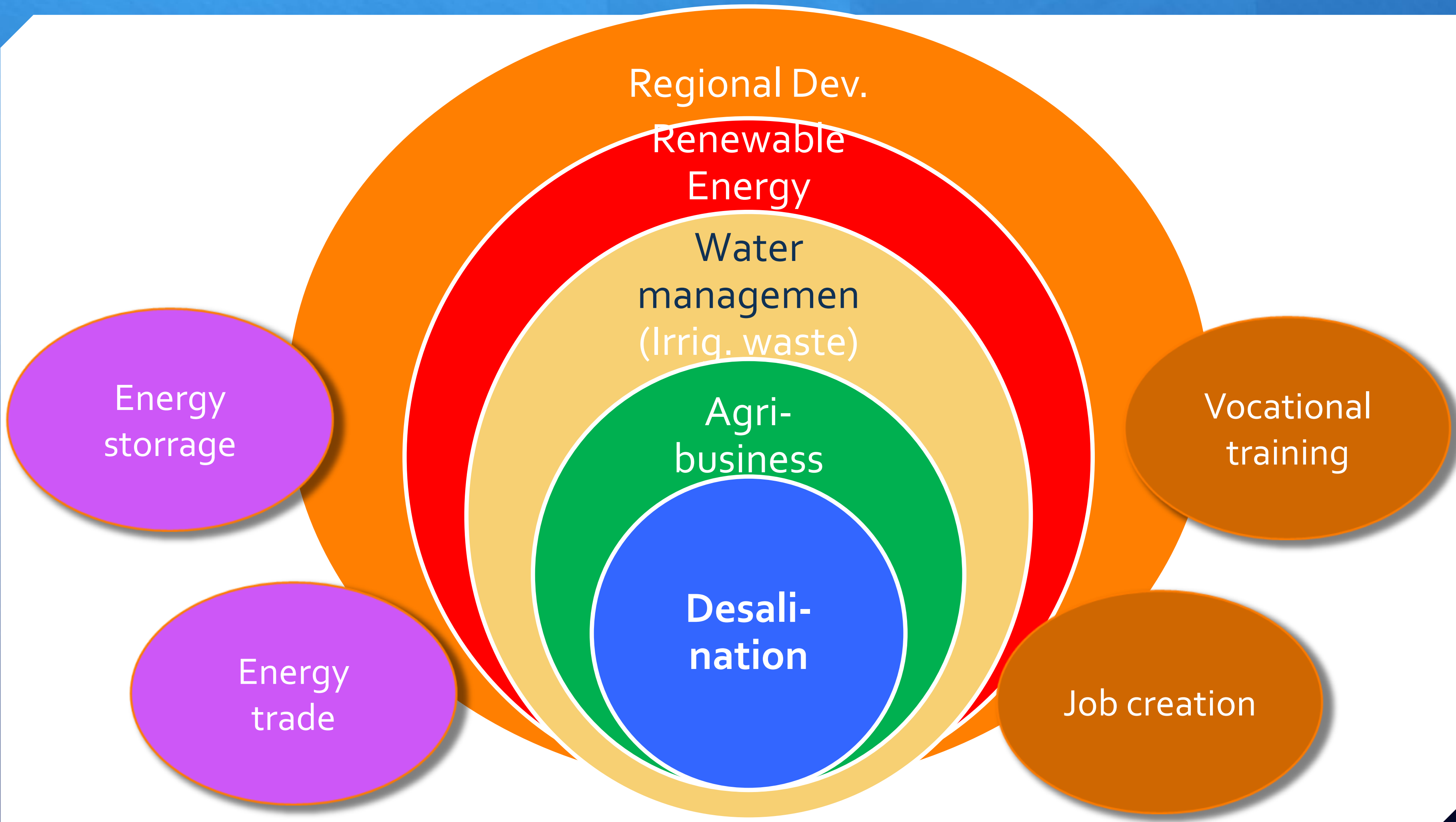
Desalinated water is precious: Enhanced drip irrigation

- + 30% cheaper…
- + 20% less water consumption…
- + Less ground salination…
- + More yield…

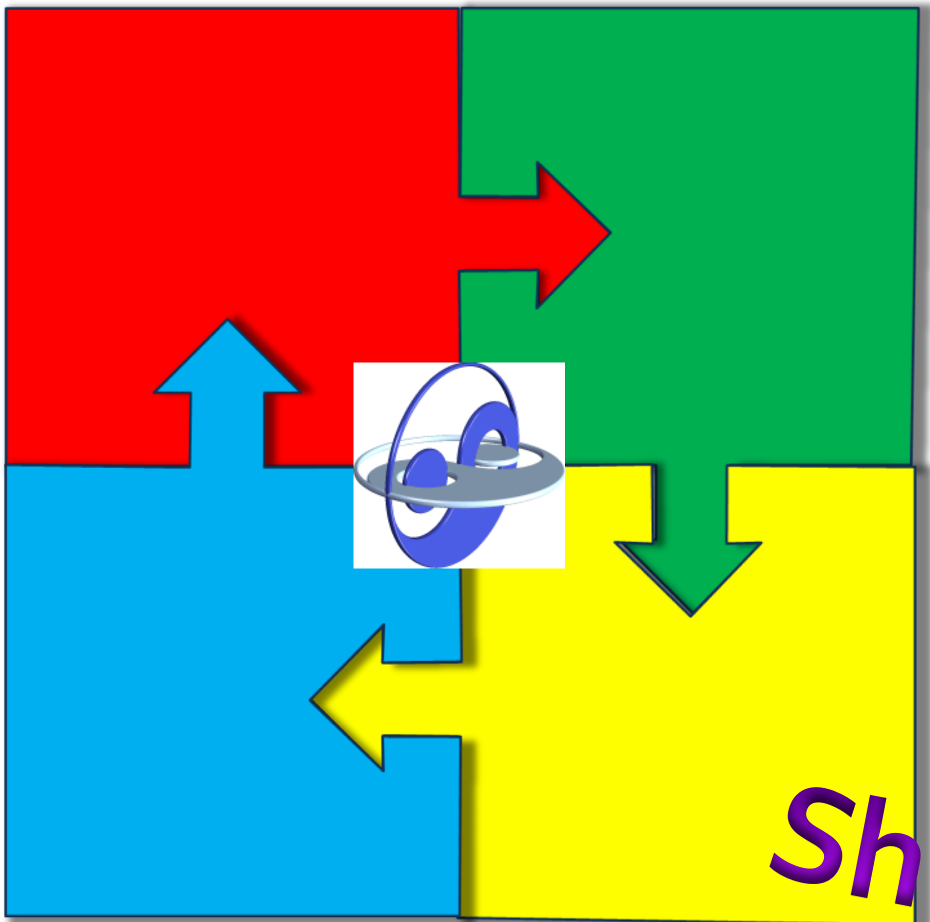
…compared to
normal drip irrigation

Experimental work at vocational training facility Berlin Zehlendorf

Desalinating Saltwater as a „Backbone" for regional development



Summary



- Find appropriate Technology
- High return of invest
- Export business, Collaboration with Europe
- Regional development
- New Jobs

Shugren, Merci